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Pixel-wise Motion Detection in Persistent Aerial Video Surveillance

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Pixel-wise Motion Detection in Persistent Aerial Video Surveillance

Prepared by LLNL under Contract DE-AC52-07NA27344.

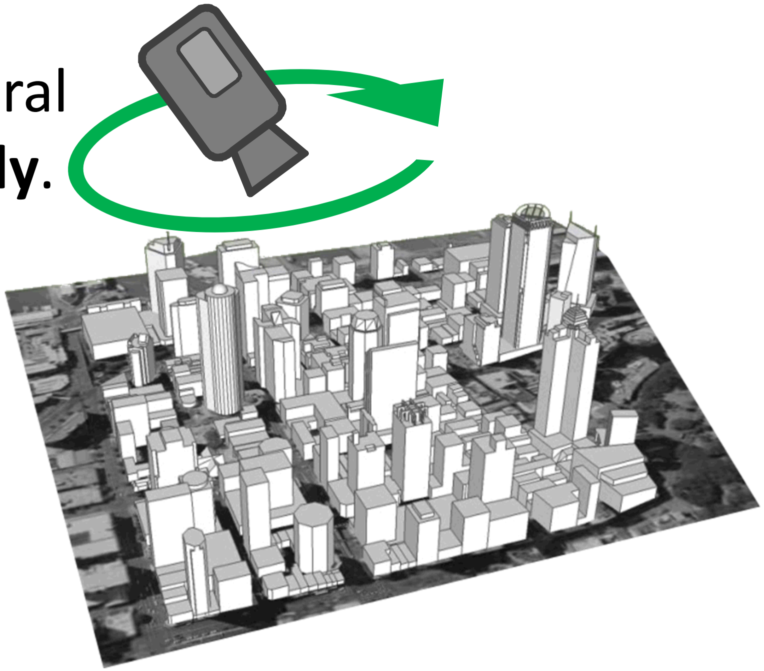
- Motivation
- Method
- Phase congruency
- Decomposition/analysis
- Motion metric
- Precession results
- Independent movers results

Motivation

In ground stabilized WAMI, stable objects with depth appear to have precessive motion due to sensor movement alongside objects undergoing true, independent motion in the scene.

Computational objective

Disambiguate independent and structural motion in WAMI **efficiently** and **robustly**.



Applications

- Increase video compression rate via object-oriented video compression
- Robustly identify moving objects for end users in sparse terrain

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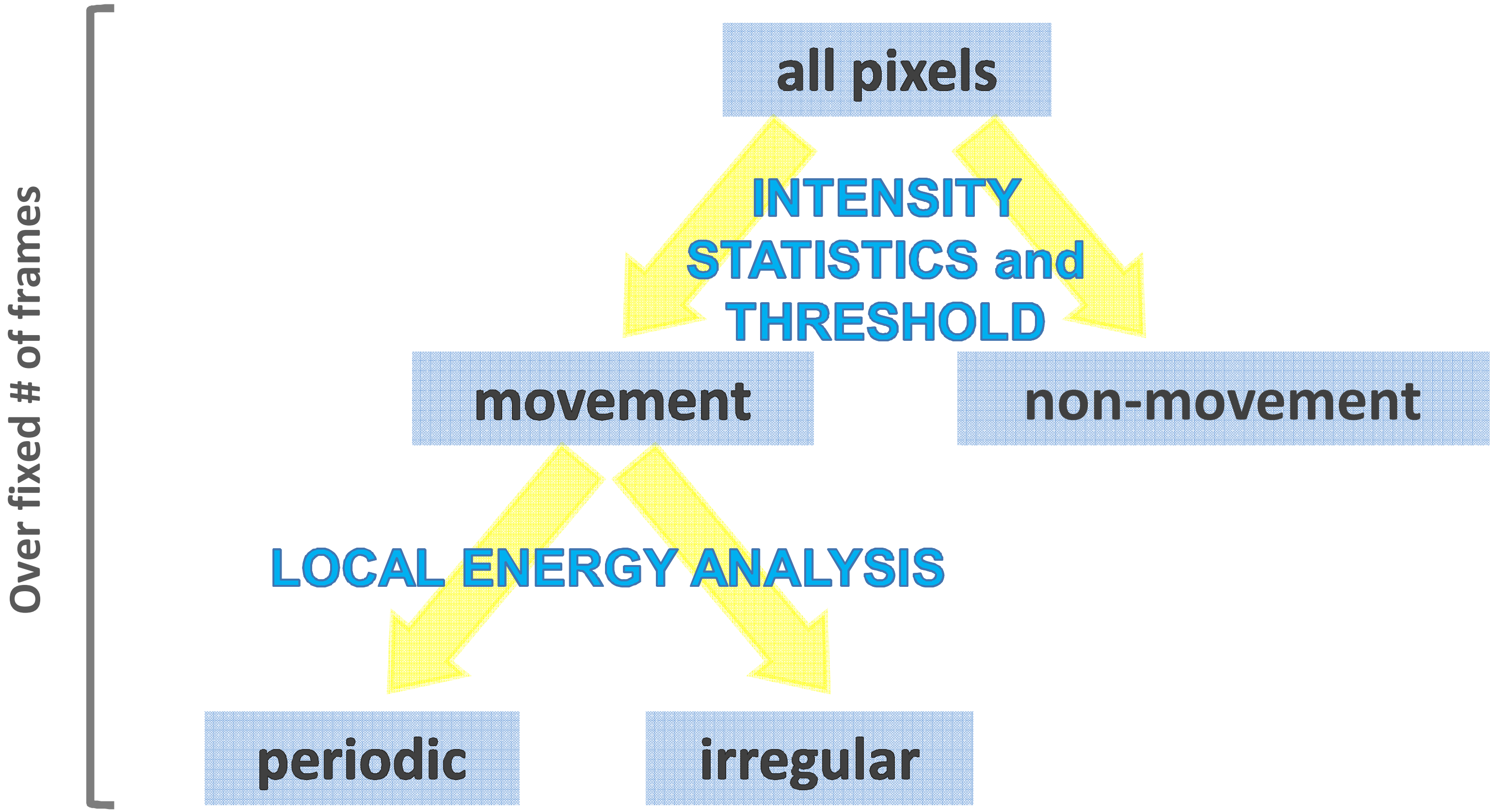
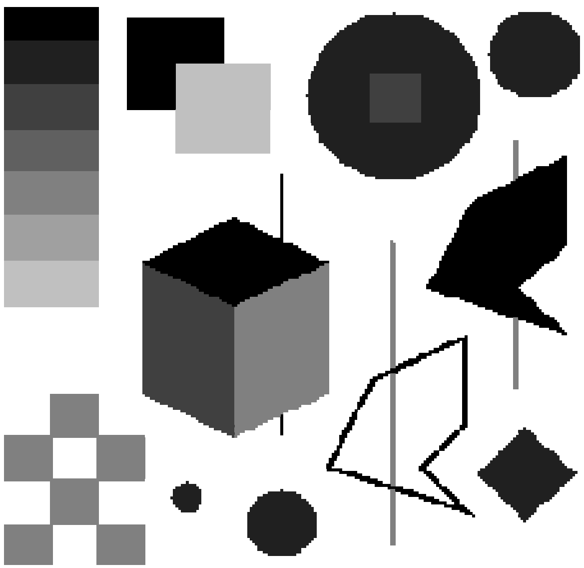
Method

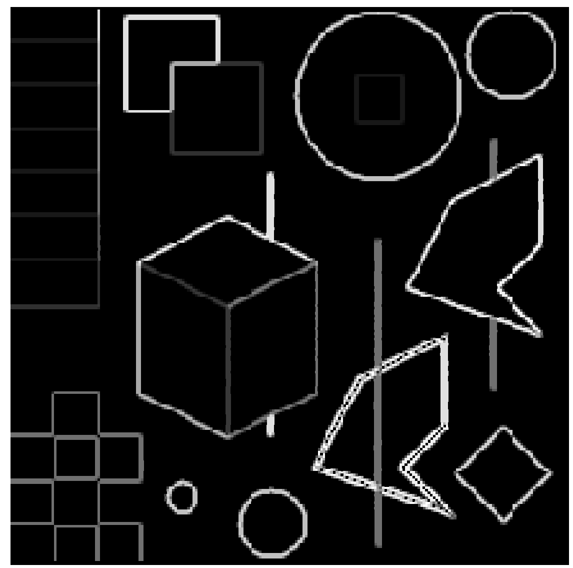

Over fixed # of frames
all pixels
INTENSITY STATISTICS and THRESHOLD
movement
non-movement
LOCAL ENERGY ANALYSIS
periodic
irregular

Phase congruency

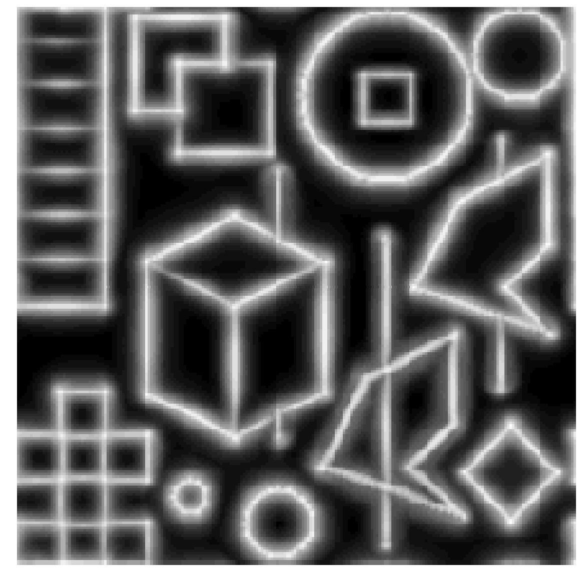
2D application in computer vision



original



Canny



phase congruency

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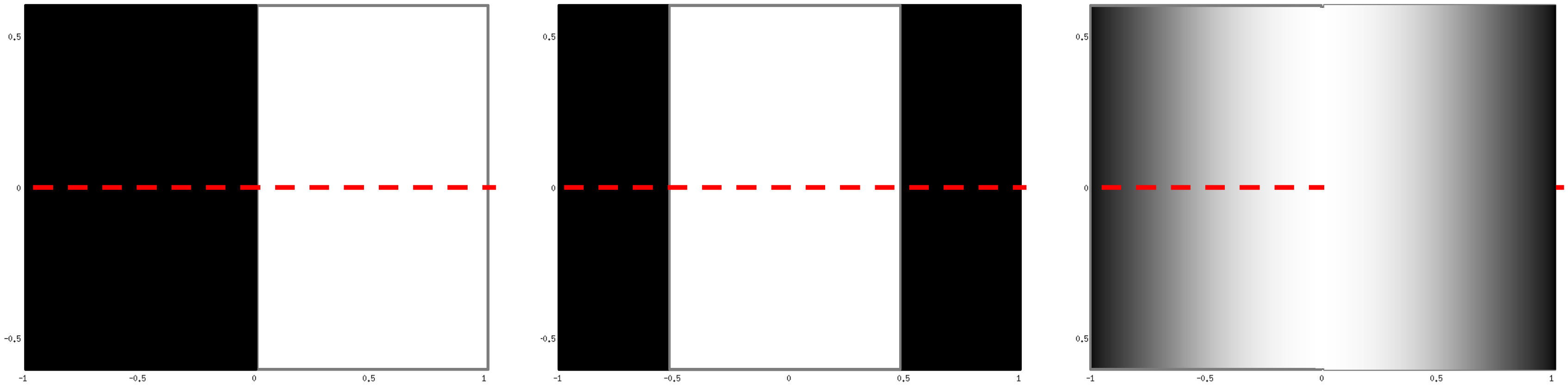
Phase congruency

Frequency components in same phase



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Analytical (de)composition

$$f = f_s \odot f_e$$
$$= f_s \cdot f_e - \tilde{f}_s \cdot \tilde{f}_e$$

f_e = smooth energy

f_s = local energy

$\tilde{f}$ = Hilbert transform of f

$$f_e = \sqrt{f^2 + \tilde{f}^2}$$
$$f_s = f \oslash f_e$$
$$= \frac{f \cdot f_e + \tilde{f} \cdot \tilde{f}_e}{{f_e}^2 + {\tilde{f}_e}^2}$$

$$f_e(x) \propto PC(x)$$

R.A. Owens. **Feature free images.** Pattern Recognition Letters, 15 (1994), pp. 35–44.

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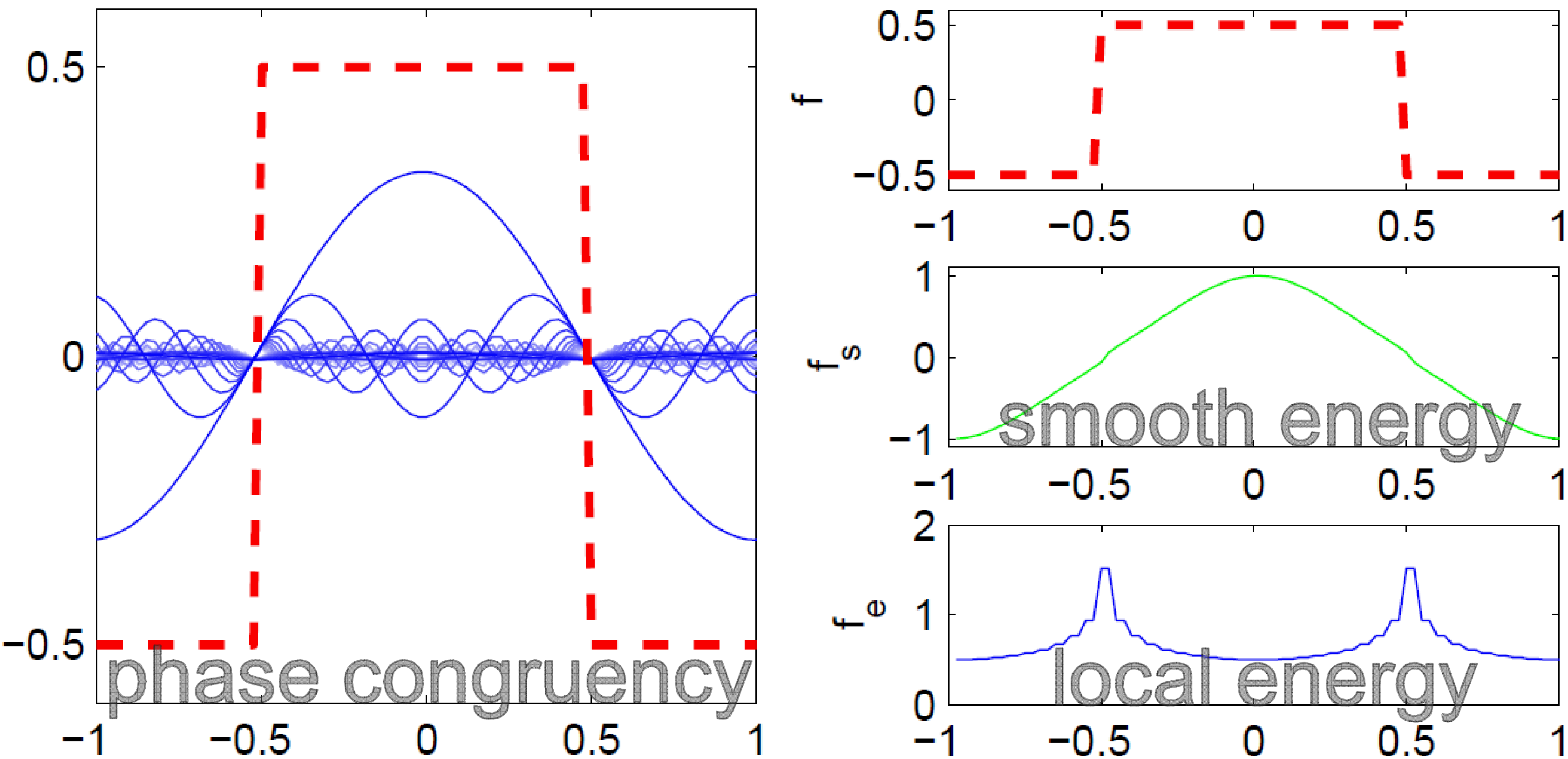
Decomposition



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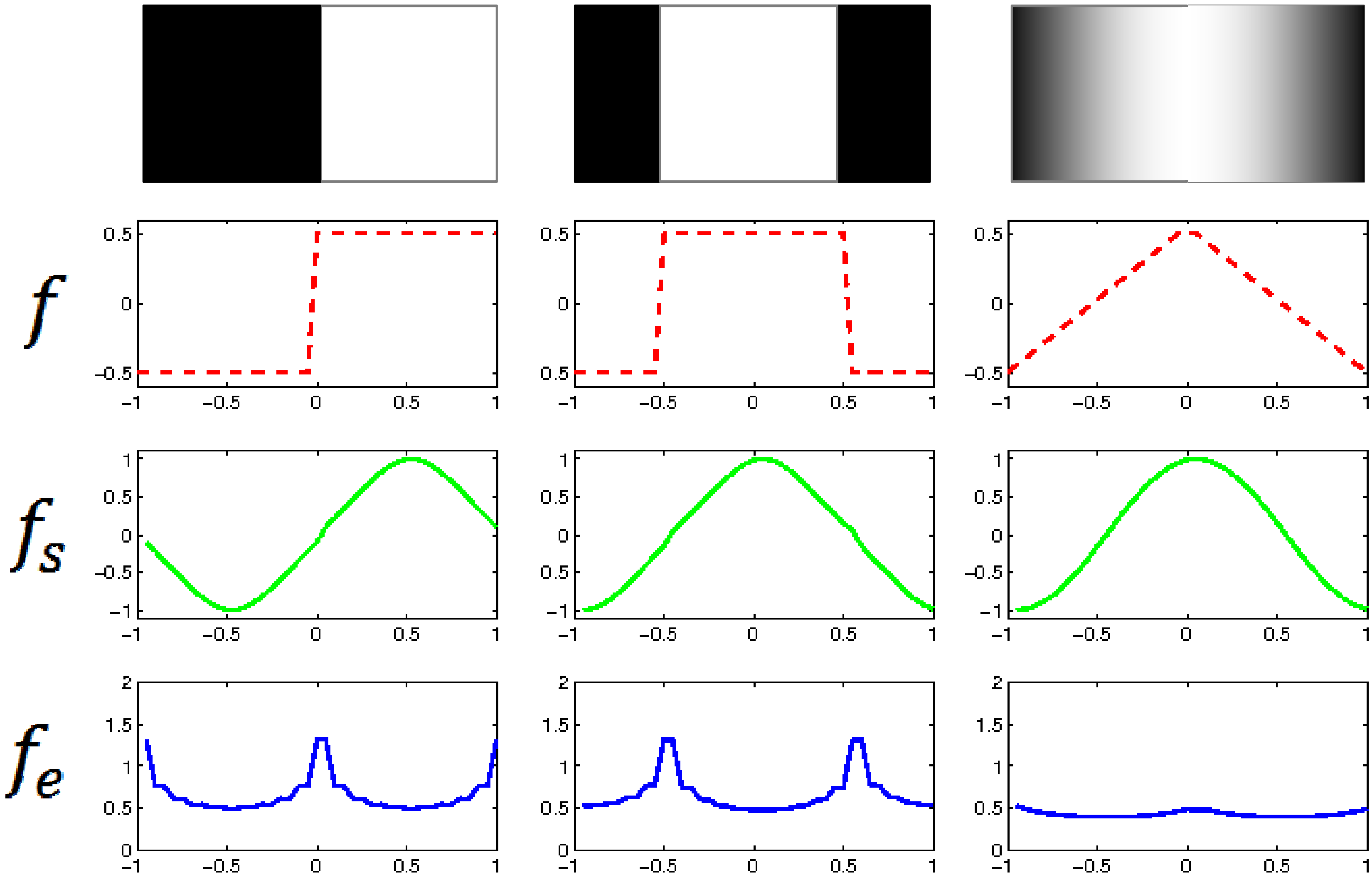
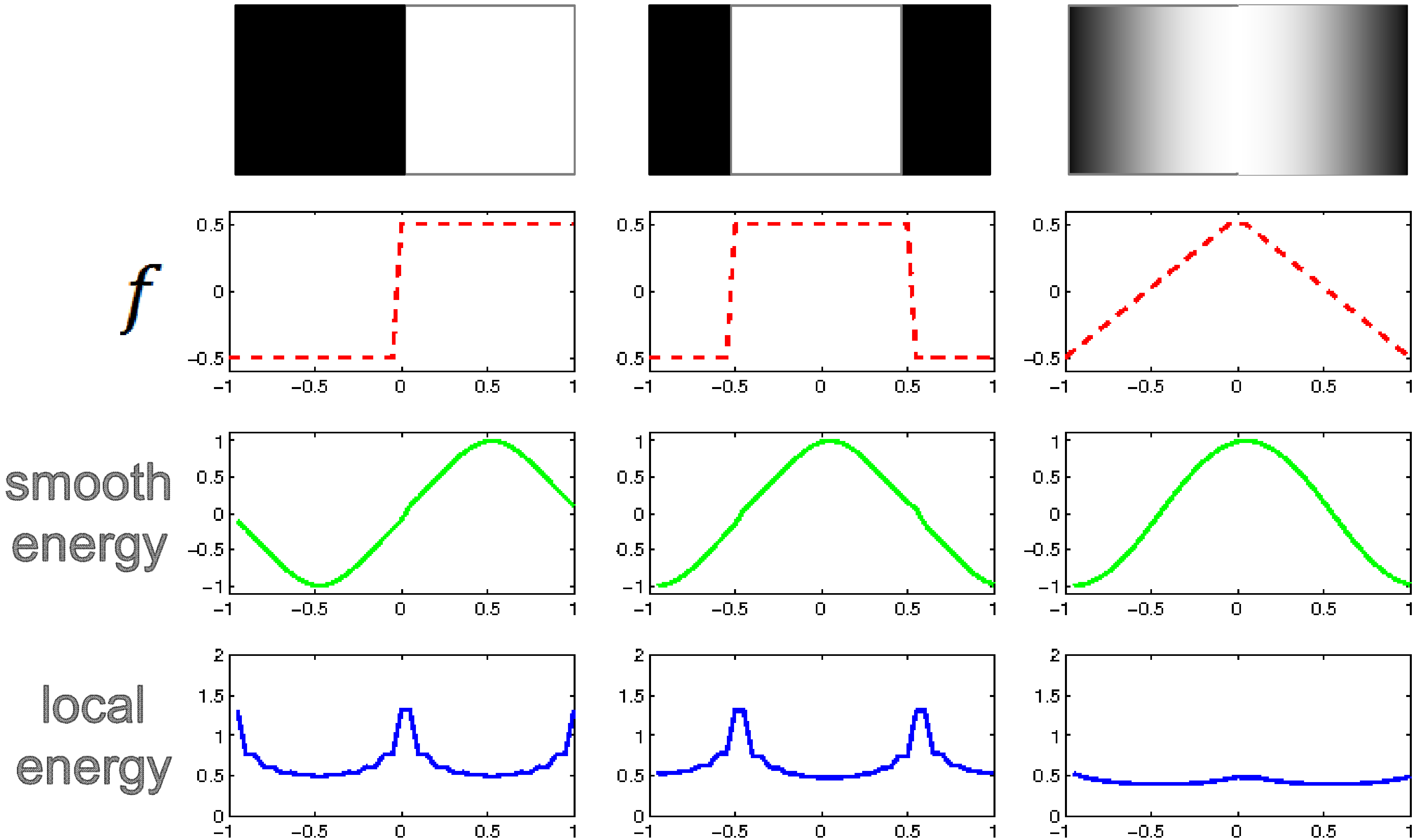
Decomposition

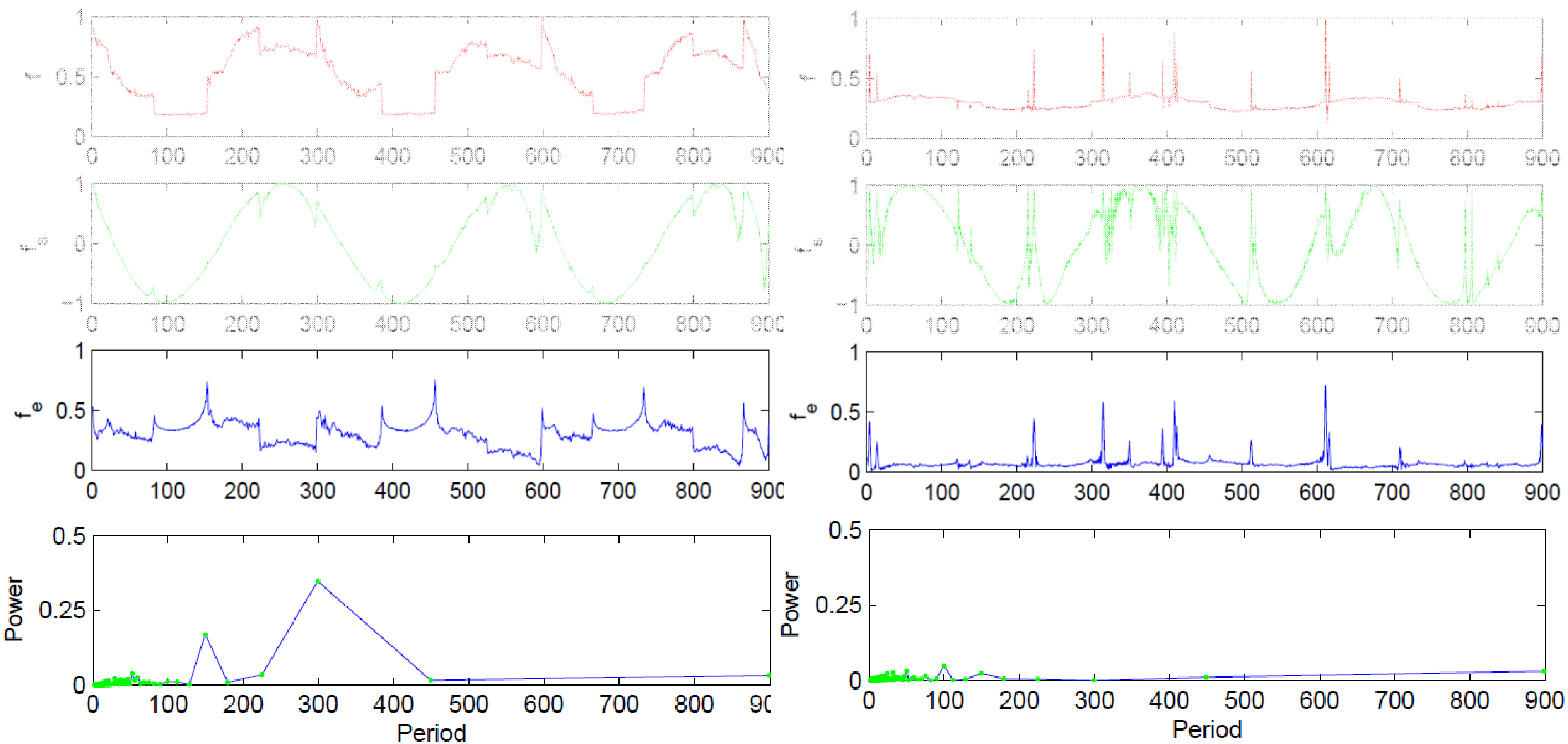


Decomposition



Decomposition

Time-frequency analysis



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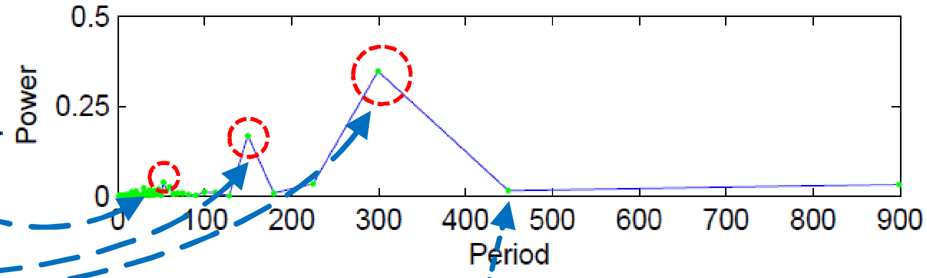
Periodicity metric

Period power spectrum for $f_e(\mathbf{x})$

Let $\mathcal{P} = \{p_1(\mathbf{x}), p_2(\mathbf{x}), \cdots, p_\tau(\mathbf{x})\}$



Motion metric

$$g(\mathbf{x}) = \sum_{i=1}^{k} p_i(\mathbf{x}), \quad k \le \tau \qquad \tau < \lfloor n/2 \rfloor$$

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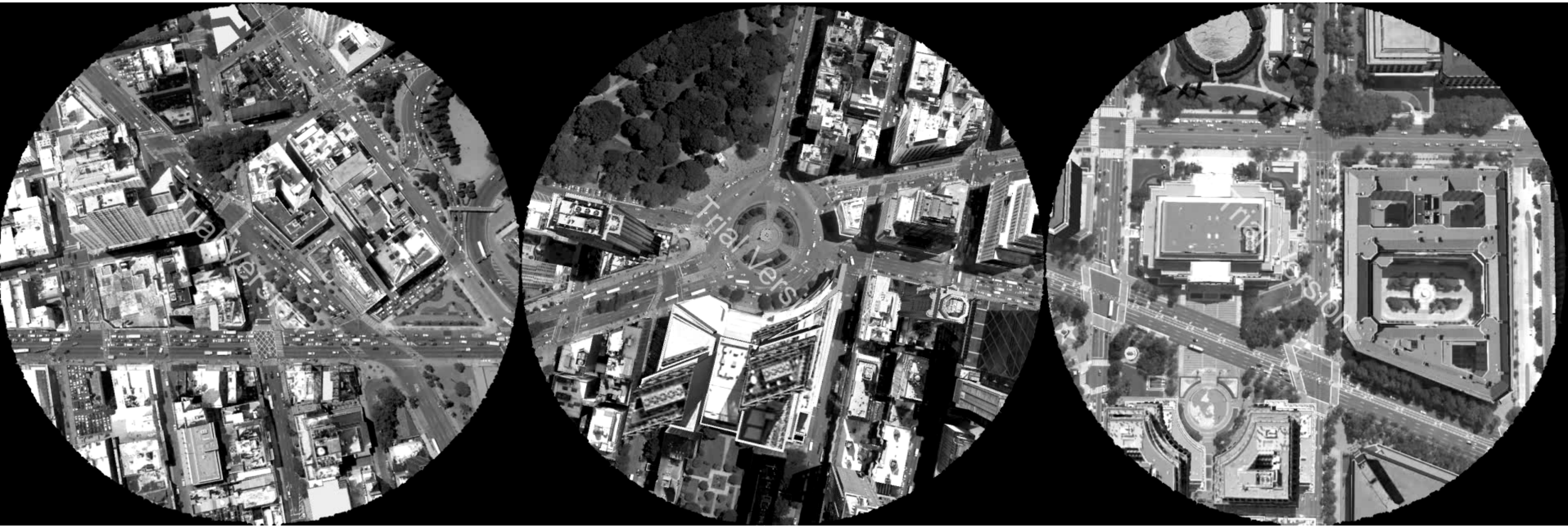
Periodic motion



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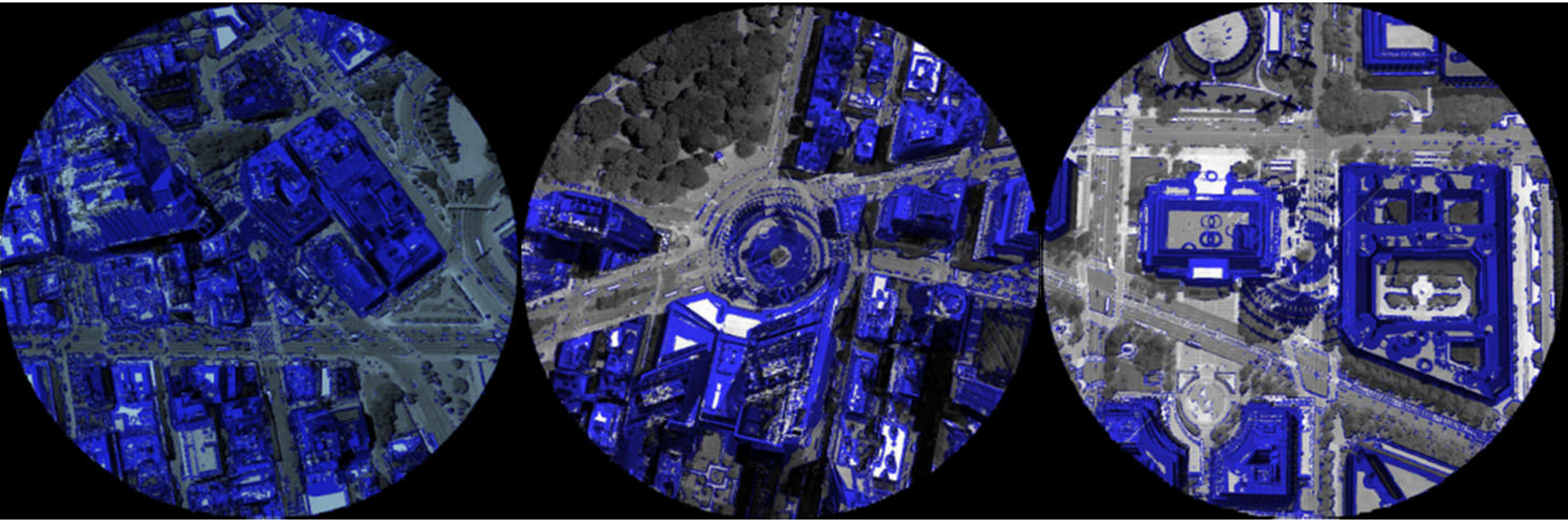
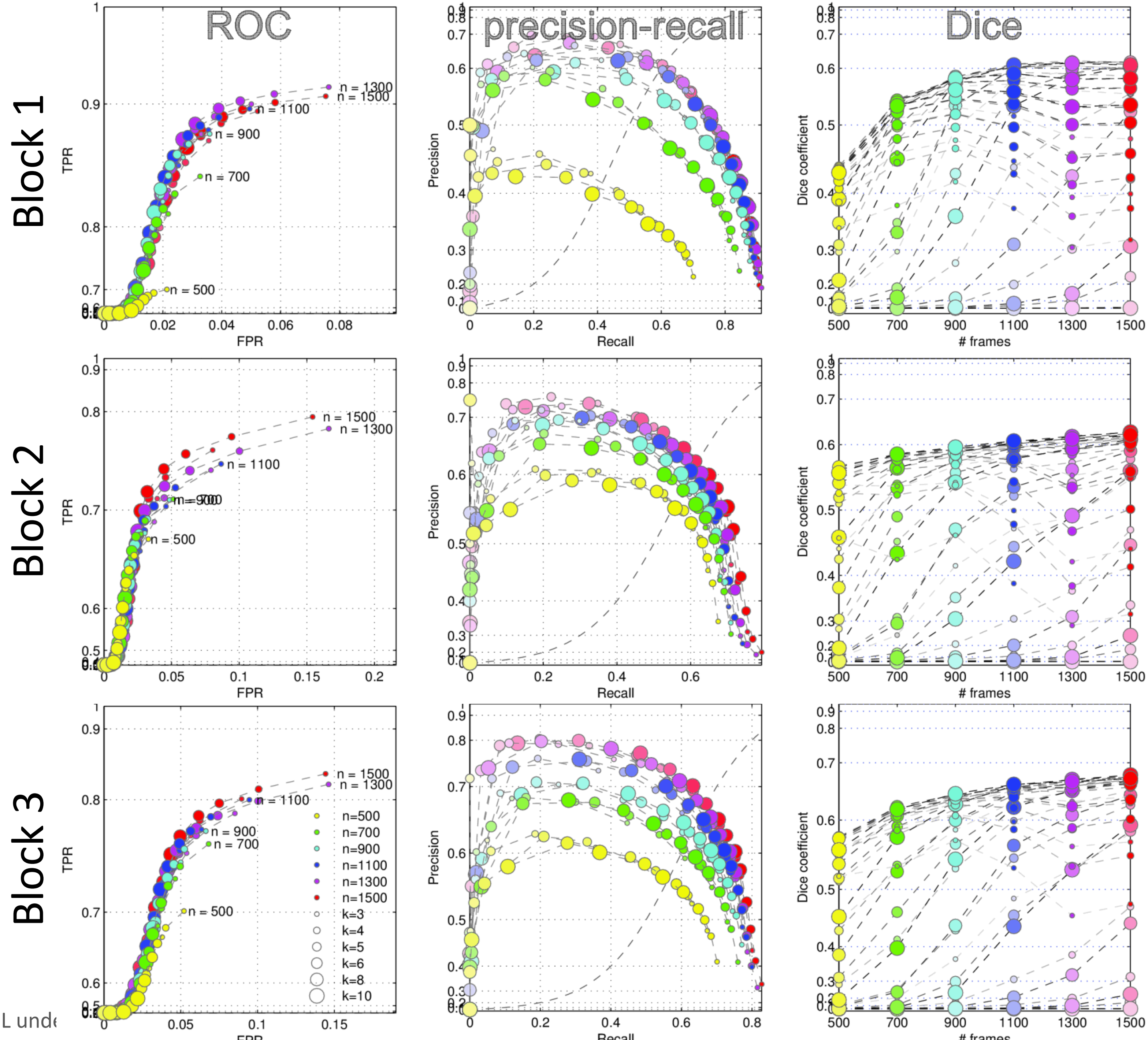
Periodic motion



Independent motion



Conclusions

- Devised motion metric based on periodicity of intensities
  - Sensitivity analysis shows balance between and will give most optimal results
  - Most optimal is 2-3 cycles of precession

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